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## I. INTRODUCTION

This report summarizes the significant research activities of the Principal Investigator William R. Schucany and Professor Henry L. Gray for the entire period 1 March 1975 to 31 December 1981 supported by ONR Contract N00014-75-C-0439, Project NR 042-280. Some background for the major results, which fit together into a coherent research program, will be given in this section. The accomplishments in several areas are then described in the following section. Section III lists the presented and published work of the investigators during the contract period. A supplemental bibliography is included at the end of this section for articles which are not included in Section III, but are needed to discuss the background.

### A. Background

Some basic concepts of the importance of error expansions in a deterministic setting and bias expansions in a stochastic framework were elucidated in two noteworthy early papers. "Higher order G-transformations" by Gray, Atchison and McWilliams (1971) and "On bias reduction in estimation" by Schucany, Gray and Owen (1971) lay a foundation in principle for many of the results in time series analysis and jackknifing that were produced during this period. More of this background is contained in the book entitled The Generalized Jackknife Statistic by Gray and Schucany (1972), which gratefully acknowledges earlier ONR support. An additional two papers in this line of development are "On the jackknife statistic and its relation

to UMVU estimators in the normal case" by Gray, Watkins and Schucany (1973) and "On Edgeworth expansions with unknown cumulants" by Gray, Coberly and Lewis (1975). These two papers represent applications of the general principle underlying the jackknife which go beyond most popular notions of the extent of the techniques.

From the foundation laid down in these early works the investigators made progress in several areas during the contract period. Professor Gray and his students pursued various new developments in the area of time series analysis using the fundamental principle as it applies to representations of the autocorrelation function. Professor Schucany and his students continued to apply and extend the concepts to approximate distribution-free procedures for handling random samples in a modeling and estimation context.

Two additional avenues of investigation that have been fruitful during the contract period are not tied closely to the bias expansion principle and yet fall within the same general scope of nonparametric problems. The goodness-of-fit developments began and broadened from the simple observations in the note "Order statistics in simulation" by Schucany (1972). The contributions to rank testing grew out of the seminal paper by Schucany and Frawley (1973) entitled "A rank test for two group concordance".

The next section contains those papers which have been referenced in the preceding section and are not given in Section III.

## B. Supplemental Bibliography

1. Gray, H. L., Atchison, T.A. and McWilliams, G.V. (1971) "Higher Order G-Transformations", SIAM J. on Numer. Anal., 8, 365-81.
2. Gray, H. L. and Schucany, W. R. (1972) The Generalized Jackknife Statistic, New York: Marcel Dekker.
3. Gray, H. L., Watkins, T.A. and Schucany, W. R. (1973). "On the jackknife statistic and its relation to UMVU estimators in the normal case", Commun. Statist., 2, 285-320.
4. Schucany, W. R., Gray, H. L. and Owen, D.B. (1971). "On Bias Reduction in Estimation", J. Amer. Statist. Assoc., 66, 524-33.
5. Schucany, W. R. (1972). "Order Statistics in Simulation", J. Statist. Comp. and Simul., 1, 281-6.
6. Schucany, W. R. and Frawley, W. H. (1973). "A Rank Test for Two Group Concordance", Psychometrika, 38, 249-58.

## II. SUMMARY OF RESEARCH ACCOMPLISHMENTS

### A. Jackknife Theory and Methods

The generalized jackknife statistic, as introduced by the investigators has been widely applied and extended. The application to nonparametric density estimation appeared in JASA Schucany and Sommers (1977). This application illustrated the additional flexibility of the generalized jackknife which permits the fruitful combination of kernel density estimators which different kernels or spreading coefficients or both. The efficiency of the jackknife as a variance estimator in a multinomial setting is illustrated again in a note on taste testing in Biometrics (1977). An important extension to the "variable jackknife" appears in "On the generalized jackknife and its relation to statistical differentials", Biometrika (1975). The potential improvement in approxi-

mate confidence and significance levels continues to be examined as a result of this "free" parameter in the variable jackknife.

The theoretical connection between jackknifing and UMVU estimation allowed the investigators to present a compilation of useful methods in "Best estimates of functions of the parameters of the Gaussian and gamma distributions" in IEEE Trans. on Reliability (1976). More insight into the small sample behavior of the studentized jackknife as an approximate  $t$  was reported by Schucany and Woodward (1977).

The impact of the jackknife on several areas of statistical modeling and estimation appears to be substantial. The recent bibliography by Parr and Schucany (1980) lists 162 papers on the jackknife of which more than 53% have appeared since 1975. New developments in this area continued to appear right up to the end of the period. The technical report by Parr and Schucany entitled "Jackknifing L-statistics with smooth weight functions" will appear in J. Amer. Statist. Assoc. in 1982. The manuscript discusses the behavior of linear combinations of order statistics (L-statistics) under jackknifing. The large sample distribution of a jackknifed L-statistic is given and the pseudo-value based variance estimator is shown to be consistent under moderate smoothness and trimming conditions on the weight function. The results are easily extended to smooth functions of L-statistics, answering a question posed by Rupert Miller in his 1974 review of jackknife theory and methodology. Monte Carlo results support the use of the large-sample theory to approximate the small-sample performance of jackknife confidence intervals.

### B. Time Series Analysis

The results of extending the fundamental principles of the 1971 papers into time series are documented in several articles. The first of importance is "The G-spectral estimator" which appeared as a major article in the Proceedings of the 1976 Tulsa Conference on Applied Time Series, published by Academic Press. The second by Gray, Kelly and McIntire (1978) appeared as a special issue of Communications in Statistics, with commentaries of J.W. Tukey, Enders Robinson, C.W. Granger and H. Akaike. This paper, entitled "A new approach to ARMA modeling", introduced a new methodology for estimating the orders,  $p$  and  $q$ , in an autoregressive -- moving average model. In addition the method allows one to construct from the data a transformation to stationarity for any roots of the characteristic equation on the unit circle, i.e., not just the real root of 1. The method has proven to be very successful, permitting the modeling of much more complex models than previous techniques. It has been demonstrated in subsequent papers that even for records as short as 25, the orders  $p$  and  $q$  can frequently be accurately identified. The articles and technical reports by Gray and Woodward near the end of the contract period illustrate the importance of this methodology in the handling of seasonal time series.

### C. Rank Tests

The previously cited article by Schucany and Frawley (1973) was the predecessor to a string of developments in the analysis of the agreement of rankings. The very early work of others on

the problem of  $m$  rankings leading to Friedman's  $X^2$  or Kendall's coefficient of concordance,  $W$ , was extended to two groups of rankings and some interesting and useful properties given by Li and Schucany (1975). The same testing procedure for the hypothesis of total discordance was also adapted to multiple groups and to situations in which the rankings are partial or incomplete in the papers by Beckett and Schucany (1976 and 1979). The results near the end of the contract period represent a shift in emphasis to non-null situations to broaden the scope of comparisons between groups of rankings. The flavor of this line of development is contained in the technical report by Palachek and Schucany (1981).

As a result of investigating the large sample behavior of the basic rank statistic for the two group problems, an interesting result was obtained. The distribution theory for bilinear forms  $\underline{X}'\underline{A}\underline{Y}$  under certain special relationships between normally distributed vectors  $\underline{X}$  and  $\underline{Y}$  is presented in Beckett, Schucany and Broffitt (1980). The non-normal asymptotic null distribution of the concordance statistic is a corollary of the theorem presented here but this problem was the impetus for the more general result.

#### D. Goodness of fit

The need for statistical computing support for much of the research on these topics, is responsible for some of the results obtained during the period. The transformation of uniform order statistics as it applies to censored samples [see Michael and Schucany (1977)] is founded to some extent upon the transformation given by Schucany (1972) for efficient simulation of order statistics. Another useful technique in random number generation is

given in Michael, Schucany and Haas (1976) and, as so often happens, was born out of necessity in the process of a Monte Carlo investigation of the jackknife for inferences about Inverse Gaussian populations. Also, previous activity in surveying statistical computing packages led to an invitation to Schucany (1978) to comment on the invited reviews of BMDP and SPSS in JASA.

The censored samples work by Michael and Schucany (1977) makes it possible to transform censored samples of certain types for a completely specified distribution to a set of statistics that are jointly distributed as a complete sample of fixed size. This is clearly of value in a goodness-of-fit context. The natural consequence of this line of investigation was a collection of existing methods for testing the goodness-of-fit hypothesis with censored samples [see Michael and Schucany (1978), Tech. Rept. No. 136]. Following the same avenue of research some intriguing findings on the sensitivity of the popular EDF statistics were obtained by Michael and Schucany (1978) [Tech. Report No. 137] using the tools of the influence curve and Bahadur efficiency. It was this familiarity with these measures of discrepancy that led to an important fresh examination of the estimators based upon the criterion of minimum distance.

#### E. Minimum Distance Estimation

The article entitled "Minimum distance and robust estimation" by Parr and Schucany (1980) was published during the reporting period in J. Amer. Statist. Assoc. The MD estimation is shown to provide an approach to robust procedures for the difficult non-

location or scale problems. Asymptotic theory and Monte Carlo results in the widely studied location-parameter case support the proposition that estimators derived by minimizing a discrepancy such as the Cramér-von Mises statistic have some excellent robustness properties. An important aspect of this methodology is that the parent population need not match the family of distributions that are projected through the discrepancy. A meaningful parameter of the projection model is estimated robustly even when the population sampled is not a member of the family.

Also during this period a paper was published in Commun. Statist. entitled "On minimum Cramér-von Mises-norm parameter estimation" by W. C. Parr and T. DeWet (1981). In this manuscript minimum distance estimation using weighted Cramér-von Mises statistics is considered for the general one-dimensional case. Under rather general conditions, the derived estimators are shown to be asymptotically normal. Consideration is given to the appropriate weights to produce Fisher-efficient estimators. In fact, estimators can be obtained with influence curves that are proportional to any desired smooth function, and hence with prescribed first-order robustness properties. Many such curves (any "redescending" influence curve) are shown to require weight functions which take on negative values.

A third accomplishment in this area during this period is reported in a manuscript entitled "Minimum distance estimation and components of goodness-of-fit statistics" by Parr and Schucany. This report was mailed to the distribution list during this reporting period and is scheduled to appear in JRSS, B. The relationships of MD estimation to other methods are given. The

The technique of M-estimation may be viewed as a special case. The extremely interesting results flow from the relationship between the defining  $\Psi$  function and the quantities known as components of certain goodness-of-fit statistics. It is shown the efficiency of the estimator is related to the fidelity with which the components match the Fourier coefficients of the efficient score function,  $J(u) = \frac{\partial}{\partial \theta} \ln f_{\theta}(x) \Big|_{x=F_{\theta}^{-1}(u)}$ . At the same time it may be seen that the robustness of the estimator is related to the tapering (or low-pass filtering) of these coefficients.

#### F. Miscellaneous

A variety of other research accomplishments were documented in the literature during the contract period. The "Bibliography for Statistical Consulting" which appeared in Biometrics (1977) has been well received. A paper entitled "Correlation Structure in Farlie-Gumbel-Morgenstern Distributions" by Schucany, Boyer and Parr (1978) in Biometrika demonstrated that this class of joint distributions with specified marginals is not very rich in the sense of the range of correlation structures that are feasible to model. Other recent technical reports continue to address various questions concerning correlation tests and estimates.

## III PUBLICATIONS AND PRESENTATIONS

A. Papers Presented by Invitation

The following presentations are all invited talks to select groups or at scientific meetings. Virtually all of them are approximately 1 hour in length. There were numerous other contributed talks that are not listed here, but they generally correspond to material in either a technical report or one of these invited talks.

Gray, H. L., "G-Spectral Estimation", Joint Meeting of American Statistical Association, Biometric Society, and Institute of Math-Stat., March 8-10, 1976, Texas A & M University.

Gray, H. L. and Schucany, W. R., "The Jackknife, Statistical Differentials, Numerical Methods, Sample Reuse - A Unifying Theory", Joint Meeting of ASA, Biometrics Society (WNAR) and IMS, Texas A&M University, March, 1976.

Gray, H. L., "G-Spectral Estimation", Symposium on Applied Time Series, May 14-15, 1976, Tulsa, Oklahoma.

Gray, H. L., "On Developing a Forecast Model", Washington, D.C., Statistical Society, September 1977.

Gray, H. L., "On G-Spectral Estimation", Princeton Statistics Seminar, September 27, 1977.

Gray, H. L., "On Developing a Forecast Model", Princeton Statistics Seminar, September 29, 1977.

Schucany, W. R., "Goodness-of-fit: Censoring and Influence Functions", Institute of Statistics, Texas A & M University, October, 1977.

Schucany, W. R., "Average Rank Correlation", Mathematics Colloquium, Stephen F. Austin University, March 1978.

Gray, H. L., "On ARMA Modeling", Texas A & M University Institute of Statistics, April, 1978.

Schucany, W. R., "Related Correlation Coefficients", Quality Theory Research Seminar, Bell Labs., West Long Beach, New Jersey, July 1978.

Papers Presented by Invitation (con't)

- Schucany, W. R., "Internal and External Rank Correlation", Kansas-Missouri ASA Chapter, Manhattan, KS., Nov. 9, 1978.
- Woodward, W. A. and Gray, H. L., "Finding an ARMA Model - The Stationary and Non-Stationary Case", 166th IMS Central Region Meeting, New Orleans, La., April 9-11, 1979.
- Gray, H. L., "ARMA Modeling by S-Arrays", 23rd Annual Technical Conference of ASQC and ASA, Minneapolis, Mn., Nov. 1-2, 1979.
- Schucany, W. R., "The influence curve and goodness-of-fit", Dept. of Statistics, Florida University, January 1980.
- Schucany, W. R., "Intergroup concordance of rankings", South Carolina Chapter ASA, Clemson, South Carolina, January 18, 1980.
- Schucany, W. R., "Page's L without random rankings", Regional meeting IMS, Iowa City, Iowa, April 30, 1980.
- Schucany, W. R., "Statistical Science v. Employment Discrimination Litigation", SREB Summer Research Conf. on Statistics, Pensacola, Florida, June 9, 1980.
- Schucany, W. R., "Intergroup Concordance as a U-statistic ", ASA National Meeting, Houston, Texas, August 13, 1980.
- Schucany, W. R., "Useful Nonparametric Techniques", AIDS National Meeting, Las Vegas, Nevada, November 1980.
- Michael, J.R. and Schucany, W.R., "A New Approach to testing goodness-of-fit for censored samples", Fall Technical Conference, Minneapolis, Minnesota, November 1980.
- Schucany, W. R., "The Jackknife: an overview", Dept. of Math. Science, Rice University, March, 1981, Dept. of Mathematics, The University of Texas, Austin, April 1981, Dept. of Statistics, Ohio State University, May 1981.
- Schucany, W. R., "Robust Statistical Methods" ONR Sponsored Naval Reserve Research Unit, ONR/NRL (TECH) 410, June 1981.

B. Published Papers

1. By the investigators

- Gray, H. L. and Foster, M. R., "Autoregressive, maximal entropy and G-Spectral estimation", Some Statistical Methods Useful in Oil Exploration (Ed., D. B. Owen), Marcel Dekker Statistics Series, Vol. 13 (1975).
- Gray, H.L., Schucany, W.R. and Watkins, T.A., "On the generalized jackknife and its relation to statistical differentials", Biometrika, 62, 637-42 (1975).

Published Papers (con't)

- Gray, H. L., Coberly, W.A. and Lewis, T. O., "On Edgeworth expansions with unknown cumulants", The Annals of Statistics, 3, 741-746 (1975).
- Li, Loretta and Schucany, W. R., "Some properties of a test for concordance of two groups of rankings", Biometrika, 62, 417-423 (1975).
- McCune, E. D. and Gray, H. L., "On Cornish-Fisher Expansions with Unknown Cumulants", Communications in Statistics, 4, 1043-56 (1975).
- Woodward, W. A. and Gray, H. L., "Minimum variance unbiased estimation in the gamma distribution", Communications in Statistics, 4, 907-922 (1975).
- Beckett, James and Schucany, W. R. "ANACONDA: Analysis of concordance of g groups of judges", Proceedings of Social Statistics Section, 1975 Joint Meetings, 311-13 (1976).
- Schucany, W. R. and Beckett, James, "Analysis of Multiple Sets of Incomplete Rankings", Communications in Statistics, A5, 1327-34 (1976).
- Michael, John R, Schucany, W. R. and Haas, R.W., "Generating random variates using transformations with multiple roots", The American Statistician, 30, 88-90 (1976).
- Gray, H. L., Schucany, W. R. and Woodward, W.A., "Best estimates of functions of the parameters of the Gaussian and gamma distributions", IEEE Transactions on Reliability, R-25, 95-99 (1976).
- Kelley, J.A., Kelley, G.D. and Schucany, W. R., "Efficient estimation of  $P(Y < X)$  in the exponential case", Technometrics, 18, 359-60 (1976).
- Woodward, W. A. and Schucany, W. R., "Combination of Preference Pattern with the Triangle Taste Test", Biometrics, 33, 31-39 (1977).
- Schucany, W. R. and Woodward, W. A., "Adjusting the Degrees of Freedom of the Jackknife", Communications in Statistics, A6, 439-42 (1977).
- Gray, H. L., "G-Spectral Estimation", Proceedings of the IEEE International Conference on Acoustic, Speech and Signal Processing, Hartford, Conn., 63-65 (1977).
- Woodward, W. A. and Schucany, W. R., "Bibliography for Statistical Consulting", Biometrics, 33, 564-5 (1977).
- Schucany, W. R. and Sommers, John P., "Improvement of Kernel Type Density Estimators", J. of the Amer. Statist. Assoc., 72, 720-3 (1977).
- Michael, John R. and Schucany, W. R., "A new approach to testing goodness-of-fit for censored samples", Technometrics 21, 435-551, (1977).
- Schucany, W. R., "Comment on 'A Review of the Manuals for BMDP and SPSS'", J. of the Amer. Statist. Assoc., 72, 92-93 (1978).

Published Papers (con't)

Gray, H. L., Houston, A.G. and Morgan, F. W., "On G-Spectral Estimation", Proceedings of the 1976 Tulsa Conference on Applied Time Series, Academic Press, (1978).

Schucany, W.R., "Comment on 'Testing for Agreement between Two Groups of Judges' by Hollander and Sethuraman", Biometrika, 65 (1978).

Schucany, W. R., Boyer, J.E. and Parr, W. C., "Correlation structure in Farlie-Gumbel-Morgenstern Distributions", Biometrika, 65, 650-653, (1978).

Gray, H.L., Kelley, G. D. and McIntire, D.D., "A New Approach to ARMA Modelling (with commentary)", Communications in Statistics, B7, 1-78 (1978).

Woodward, W.A. and Gray, H. L., "A New Model for Wölfer's Sunspot Numbers", Communications in Statistics, B7, 97-115, (1978).

Schucany, W. R., Mansfield, E.R., Woodward, W.A., Hess, J. L., "Analysis of the Reliability of a New Scale for Housing Quality", J. Statist. Planning and Inf., 3, 305-313 (1979).

Beckett, James and Schucany, W. R., "Concordance among categorized groups of judges", J. Edu. Statist., 4, 125-137, (1979).

Parr, W.C. and Schucany, W. R., "Robustness of minimum distance estimation", J. Amer. Statist. Assoc., 75, 616-624, (1980).

Beckett, James, Schucany, W.R. and Broffitt, James, "A Special Distributional Result for Bilinear Forms", J. Amer. Statist. Assoc., 75, 466-468, (1980).

Parr, W.C. and Schucany, W. R., "The Jackknife: A bibliography", International Statistical Review, 48, 73-78, (1980).

Gray, H. L. and Woodward, W.A., "Application of S-arrays to seasonal data", Applied Time Series Analysis II, D. Findley, Ed., Academic Press, 379-413 (1981).

Woodward, Wayne A. and Gray, H. L., "On the relationship between the S-array and the Box-Jenkins method of ARMA model identification", J. Amer. Statist. Assoc., 76, 579-587 (1981).

2. By Former Students and Other Researchers acknowledging ONR support

Owen, D. B., McIntire, D. and Seymour, E., "Tables using one or two screening variables to increase acceptable product under one-sided specifications", Journal of Quality Technology, 7, 127-138, (1975).

### Published Papers (con't)

- Patel, Jagdish, "Bounds on moments of linear functions of order statistics from Weibull and other restricted families", J. of Amer. Statist. Assoc., 70, 670-3, (1975).
- Gunst, R. F., Webster, J.T. and Mason, R. L., "A Comparison of least squares and Latent Root Regression estimators", Technometrics, 18, 75-83, (1976).
- Gunst, R. F., and Mason, R. L., "Generalized Mean Square Error Properties of Regression Estimators", Commun. in Statist., A5, 1501-8, (1976).
- Woodward, W.A., "Approximations of Pearson Type IV tail probabilities", J. of the Amer. Statist. Assoc., 71, 513-4, (1976).
- Woodward, W. A., "Subroutines for Computing Minimum Variance Unbiased Estimators of Functions of the Parameters in the Normal and Gamma Distributions", Commun. in Statist., B6, No. 1, (1977).
- Woodward, W. A. and Kelly, G.E., "Minimum Variance Unbiased Estimation of  $P(Y < X)$  in the Normal Case", Technometrics, 19, 95-98, (1977).
- Parr, W.C., "A conditional property of adaptive estimators", J. Statist. Comput. Simul., 10, 289-295, (1980).
- Woodward, W.A. and Frawley, W.H., "One-Sided Tolerance Limits for a Broad Class of Lifetime Distributions with Applications to Data for Limited Accuracy", J. Quality Technology, 12, 130-137, (1980).
- Parr, W. C. and DeWet, T., "On minimum Cramér-von Mises-norm parameter estimation", Commun. Statist., A10, 1149-1161, (1981).

### C. Technical Reports

Most of the following reports are in various stages of review or revision for publication in a variety of journals. Unless the paper has received final acceptance by the Editor, no annotation of the journal is made.

- Boyer, John E. and Schucany, W.R., "On Wolfe's test for related correlation coefficients", Tech. Report No. 127, Department of Statistics, SMU, (1978).
- Michael, J.R. and Schucany, W.R., "Analysis of data from censored samples", to appear as Chapter 12 (70 pages) in Handbook of Goodness of Fit, Ed. R. D'Agostino, Marcel Dekker, Inc., Tech. Report No. 136, Department of Statistics, SMU, (1978).

Published Papers (con't)

Michael, J. R. and Schucany, W.R., "The influence-curve and goodness of fit", Tech. Report No. 137, Department of Statistics, SMU, (1978).

Parr, W. C. and Schucany, W.R., "Jackknifing L-statistics with smooth weight functions", to appear J. Amer. Statist. Assoc., Tech. Report No. 138, Department of Statistics, SMU, (1980).

Parr, W. C. and Schucany, W. R., "Minimum distance estimation and components of goodness-of-fit statistics", to appear in J. Roy. Statist. Soc., Tech. Report No. 139, Department of Statistics, SMU (1980).

Hart, J.D. and Gray, H.L., "Modeling Seasonal ARMA Processes", Tech. Report No. 140, Department of Statistics, SMU, (1980).

Morton, Mike, "The Determination of Seasonal ARMA Models", Tech. Report No. 141, Department of Statistics, SMU, (1980).

Eubank, R. L., "A regression design approach to optimal and robust spacing selection." Tech. Report No. 144, Department of Statistics, SMU, (1981).

Eubank, R. L., "On the Computation of Optimal Designs for Certain Time Series Models with Applications to Optimal Quantile Selection for Location or Scale parameter estimation", Tech. Report No. 146, Department of Statistics, SMU (1981). To appear SIAM J. Sci. Stat. Comput.

Eubank, R. L. and LaRiccia, V.N. "Weighted  $L^2$  quantile distance estimators for randomly censored data." Tech. Report No. 149, Department of Statistics, SMU, (1981).

Eubank, R. L., Smith, P. L. and Smith, P. W. "Uniqueness and eventual uniqueness of optimal designs in certain time series models II". Tech. Report No. 150, Department of Statistics, SMU, (1981).

Eubank, R. L., Smith, P. W. and Smith, P. L., "Asymptotically Optimal designs for some time series models". Tech. Report No. 151, Department of Statistics, SMU (1981).

Palachek, A.D. and Schucany, W. R., "On Approximate Confidence Intervals for Measures of Concordance", Tech. Report No. 152, SMU, (1981).

Beckett, James, Schucany, W. R. and Bosmia, N.J., "Testing the correlation coefficient with incomplete observations", Tech. Report No. 153, Department of Statistics, SMU, (1981).

Gray, H. L. and Hart, J.D., "Utilizing Complex-Valued S-arrays in the modeling of ARMA processes", Tech. Report No. 154, Department of Statistics, SMU, (1981).

Eubank, R. L., "A density-quantile function approach to adaptive location or scale parameter estimation". Tech. Report No. 155, Department of Statistics, SMU, (1981).

Hart, Jeff and Gray, H. L., "On ARMA Probability Density Estimation", Tech. Report No. 156, Department of Statistics, SMU, (1981).

